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U.S. APPLICATION NUMBER NO.	FIRST NAMED APPLICANT	ATTY. DOCKET NO.
10/088,464	James W. Schmitkons	Nor-951A

INTERNATIONAL APPLICATION NO.	
PCT/US00/25282	
I.A. FILING DATE	PRIORITY DATE
09/15/2000	09/20/1999

37172
WOOD, HERRON & EVANS, LLP (NORDSON)
2700 CAREW TOWER
441 VINE STREET
CINCINNATI, OH 45202

CONFIRMATION NO. 8796

371 WITHDRAWAL NOTICE

OC000000022228478

Date Mailed: 01/30/2007

WITHDRAWAL OF PREVIOUSLY SENT NOTICE

LAMONT M HUNTER

Telephone: (703) 308-9140 EXT 201

PART 1 - ATTORNEY/APPLICANT COPY

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PART 3 - OFFICE COPY

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I.A. FILING DATE	PRIORITY DATE
09/15/2000	09/20/1999

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PART 3 - OFFICE COPY

SJ-US030591

OCT 26 2006

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of	:	**Mail Stop Missing Parts**
Keizo MASUYAMA	:	Patent Art Unit: 3722
Serial No.: 10/570,327	:	
Filed: March 2, 2006	:	
For: ROTARY MILLING CUTTER AND MILLING METHOD USING THE SAME TECHNICAL FIELD	:	

REQUEST FOR CORRECTION OF FILING RECEIPT

Assistant Commissioner of Patents
Assignment Division
Washington, DC 20231

Sir:

Applicant noticed errors in Recordation Date on the Filing Receipt. Specifically, the Filing Date was incorrectly typed as

"03/03/2006"

while it should be

-- 03/02/2006 --.

Further, the title was incorrectly entered as

"ROTARY CUTTING TOOL AND CUTTING METHOD USING THE SAME"

while it should be

--ROTARY MILLING CUTTER AND MILLING METHOD USING THE SAME TECHNICAL FIELD --.

Attached is a copy of the Filing Receipt received from the PTO in the above application, with the corrections noted thereon. Issuance of a corrected Filing Receipt is respectfully requested. Also attached is Exhibit A, which is a copy of the postcard receipt showing that the application was filed on March 2, 2006.

The corrections are not due to Applicant error, therefore, no fee is due.

To Ms. Johnson-
Vessels
regarding our
conversation.

571-270-9973

Check on it

Due Date: 3/5/06

Today's Date: 3/2/06

USSN/USP: New (National Phase of PCT/JP2004/011888) Shinjyu File No.: SJ-US030591 By: TMG / nat

In Re: Keizo MASUYAMA

IAP7 Rec'd PCT/PTO 02 MAR 2006

For: ROTARY MILLING CUTTER AND MILLING METHOD USING THE SAME
TECHNICAL FIELD

10/570327

The following was received in the U.S. Patent and Trademark Office on the date stamped hereon:

- ☒ Check(s) for $ 940
- ☒ Translation of Specification 17 pgs. 10 claims
- ☒ Drawings 9 Sheets ☒ Formal ☐ Informal
- ☒ Combined Declaration & Power of Attorney
- ☐ Declaration
- ☐ Power of Attorney
- ☐ Certificate Under 37 C.F.R §3.73(b)
- ☒ Assignment with Cover Sheet
- ☒ Application Data Sheet
- ☐ Claim for Priority & Document(s)
- ☐ Completion of Application
- ☒ Submission of Translation
- ☒ Form 1449
- ☒ Form PCT/IB/308
- ☒ PCT/RO/101
- ☒ Form PCT/IB/345 & Informal Comments on WO/ISA
- ☐ Amendment ☐ Response
- ☐ Notice of Appeal
- ☐ Brief ☐ Req. Oral Hearing
- ☐ Issue/Publication Fee Transmittal
- ☒ Information Disclosure Statement
- ☒ Number of IDS References cited 6
- ☐ Petition to Extend mos.
- ☐ RCE
- ☒ Preliminary Amendment
- ☒ Number of references attached 5
- ☒ Application Cover
- ☐
- ☒ Form PCT/ISA/210
- ☒ Form PCT/IB/304
- ☒ A copy of International publication
- ☒ Formal Substitute Drawing 1 sheet

EXHIBIT A

CERTIFICATE OF FACSIMILE TRANSMISSION
I hereby certify that this correspondence is being deposited via facsimile to The Honorable Commissioner in the United States Patent and Trademark Office, Attention: Joseph L. Williams whose telephone number is (571) 272-2465 and centralized facsimile number is (703) 872-9306 on August 16, 2004.

David H. Brinkman 8/16/04
Date

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PATENT

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

Applicant:	Schmitkons et al.
Serial No.:	10/088,464
Filed:	March 19, 2002
Group Art Unit:	2879
Confirmation No.:	8796
Examiner:	Williams, Joseph L.
Title:	**APPARATUS AND METHOD FOR GENERATING ULTRAVIOLET RADIATION**
Atty Docket No.:	NOR-951A

Cincinnati, Ohio 45202 August 16, 2004

Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450

CHANGE OF ADDRESS AND REQUEST FOR CORRECTION OF FILING RECEIPT

Sir:

It is requested that a corrected filing receipt be issued in the above-reference application to include Applicants' customer number 37,172. Please also note this customer number in the Patent Application Information Retrieval system. A Change of Correspondence Address, Form PTO/SB/122, is enclosed.

Applicants do not believe that any fees are due in connection with this submission. However, if such petition is due or any fees are necessary, the commissioner may consider this to be a request for such and charge any necessary fees to Deposit Account No. 23-3000.

Respectfully submitted,

WOOD, HERRON & EVANS, L.L.P.

David H. Brinkman
Reg. No. 40,532

2700 Carew Tower
441 Vine Street
Cincinnati, OH 45202
(513) 241-2324 - Voice
(513) 421-7269 - Facsimile

PMG300C Application Processing History - 10088464

File View Edit Application Processing Options Window Help

- PICS Scanning Operation, SAMUEL ARAYA, 05/29/2002 - 06/07/2002
- Incoming Correspondence
- 05/24/2002 - 05/24/2002, Corrected/Replacement Filing Receipt
  - Outgoing Correspondence
    - Replacement Filing Receipt, 05/24/2002, File Date 03/18/2002
  - Worker Task
    - Filing Receipt Correction, Worker id C46181 not found, 05/24/2002 - 05/24/2002
  - Incoming Correspondence
- 04/03/2002 - 05/21/2002, Initial Cycle, 371 Complete on 05/16/2002, Withdrawn
  - Outgoing Correspondence
    - Filing Receipt, 05/21/2002, File Date 03/18/2002
    - 371 Acceptance Notice, 05/21/2002, File Date 03/18/2002
  - Worker Task
    - Pre-exam Formalities Review, Worker id C46181 not found, 05/21/2002 - 05/21/2002
    - Pre-exam Formalities Review, LAMONT HUNTER, 05/16/2002 - 05/16/2002
    - Pre-exam Formalities Review, LAMONT HUNTER, 05/16/2002 - 05/16/2002
    - Bib Data Maintenance, Worker id C46181 not found, 05/08/2002 - 05/08/2002
    - Application Patent Case Initialization, LISA HOANG, 04/03/2002 - 04/03/2002
  - Incoming Correspondence
    - Postcard, 03/19/2002
    - Copy of the International Search Report, 03/18/2002
    - Initial Basic National Fee, 03/18/2002
    - Copy of the International Application, 03/18/2002
    - Drawings, 03/18/2002
    - Oath or Declaration, 03/18/2002
    - Information Disclosure Statements, 03/18/2002
    - Request for Immediate Examination, 03/18/2002
    - Assignment, 03/18/2002
    - Initial Application Filing Fees, 03/19/2002

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PMG300C Application Processing History - 10088464

File View Edit Application Processing Options Window Help

- 10/088,464
  - 12/27/2006 - , Resend Outgoing Correpondence
    - Outgoing Correspondence
    - Worker Task
      - Process Rescind Request, TERRY JOHNSON VESSELS, 12/27/2006
    - Incoming Correspondence
  - 05/18/2004 - , Corrected/Replacement Filing Receipt
    - Outgoing Correspondence
      - 371 Pre-exam Action Withdrawal Notice, 01/30/2007
    - Worker Task
      - Filing Receipt Correction, CATHERINE SHORT, 05/18/2004
    - Incoming Correspondence
  - 05/18/2004 - 12/27/2006, Applicant Response
    - Outgoing Correspondence
    - Worker Task
      - Pre-exam Troubleshooting Applications, TERRY JOHNSON VESSELS, 12/27/2006 - 12/27/2006
      - Pre-exam Formalities Review, LAMONT HUNTER, 12/20/2006 - 12/27/2006
      - Pre-exam Troubleshooting Applications, TERRY JOHNSON VESSELS, 04/07/2006 - 12/20/2006
      - Pre-exam Troubleshooting Applications, CATHERINE SHORT, 05/18/2004 - 05/18/2004
      - Pre-exam Formalities Review, LAMONT HUNTER, 05/18/2004 - 05/18/2004
      - Pre-exam Troubleshooting Applications, CATHERINE SHORT, 05/18/2004 - 05/18/2004
    - Incoming Correspondence
  - 05/29/2002 - 06/13/2002, Applicant Response
    - Outgoing Correspondence
    - Worker Task
      - PICS Scanning Operation, SAMUEL ARAYA, 05/29/2002 - 06/07/2002
    - Incoming Correspondence
  - 05/24/2002 - 05/24/2002, Corrected/Replacement Filing Receipt
    - Outgoing Correspondence

Performs screen print | tjvessels | 02/01/2007

Several errors were noted in the Filing Receipt issued in connection with the above-identified application for which correction is respectfully requested:

1. The total number of claims is listed incorrectly as being "11" rather than the correct number of "29" as appears in the application.

2. The number of drawings is listed incorrectly as being "2" rather than the correct number of "4".

3. The filing date is listed incorrectly on the Replacement Filing Receipt and the Notice of Acceptance of Application under 35 U.S.C. 371 and 37 C.F.R. 1.494 or 1.495 as being "03/18/2002" rather than the correct date of "03/19/2002" as appears on all of the documentation filed with the Commissioner of Patents and Trademarks, Box PCT, copies attached. The United States Postal Service inadvertently put an incorrect date of 03/18/02 on the Express Mail Label. As evidenced from the delivery confirmation attached, the United States Patent and Trademark Office received the above-identified application on March 20, 2002, which indicates that the Express Mail was processed on March 19, 2002 by the United States Postal Service.

It is therefore respectfully requested that a new corrected filing receipt be issued to reflect corrections in (i) the total number of claims filed; (ii) the number of drawings; and (iii) the filing date.

It is believed that no fees are due in connection with this correction, however, the Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Account No. 23-3000.

AUG. 16. 2004 1:39PM 513 241 6234

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AUG 1 6 2004

WOOD, HERRON & EVANS, L.L.P.
2700 Carew Tower
441 Vine Street
Cincinnati, Ohio 45202-2917
Telephone: 513-241-2324
Facsimile: 513-241-6234
EMAIL: info@whepatent.com

PATENT, TRADEMARK, COPYRIGHT
AND UNFAIR COMPETITION LAW
AND RELATED LITIGATION

EDMUND P. WOOD 1923-1968
TRUMAN A. HERRON 1935-1976
EDWARD B. EVANS 1936-1971

FACSIMILE COVER SHEET

If transmission is interrupted or of poor quality, please notify us immediately by calling 513 \ 241-2324. Ask for sender's secretary.

TO:	**The Honorable Commissioner** **Attention: Joseph L. Williams** **Art Unit 2879**	**FROM:**	**David H. Brinkman**
Fax No.:	**(703) 872-9306**	**Phone:**	**(513) 241-2324**
Date:	**August 16, 2004**	**Fax:**	**(513) 241-6234**

Pages (including cover page): 4

Re: **U.S. Serial No. 10/088,464 APPARATUS AND METHOD FOR GENERATING ULTRAVIOLET RADIATION**
Attorney Docket No. NOR-951A

ATTACHMENTS/COMMENTS: **OFFICIAL**

Please deliver to Joseph L. Williams

Change of Address and Request for Correction of Filing Receipt (2 pages)
Change of Correspondence Address Form PTO/SB/122 (1 page)

CERTIFICATE OF FACSIMILE TRANSMISSION

I hereby certify that this correspondence is being facsimile transmitted to the Patent and Trademark Office centralized facsimile number (703) 872-9306 on the date shown below.

August 16, 2004

David H. Brinkman Date

PTO/SB/122 (06-03)
Approved for use through 11/30/2005. OMB 0651-0035
U.S. Patent and Trademark Office; U.S. DEPARTMENT OF COMMERCE
Under the Paperwork Reduction Act of 1995, no persons are required to respond to a collection of information unless it displays a valid OMB control number.

CHANGE OF CORRESPONDENCE ADDRESS
Application

Address to:
Commissioner for Patents
P.O. Box 1450
Alexandria, VA 22313-1450.

Application Number	10/088,464
Filing Date	March 19, 2002
First Named Inventor	James W. Schmitkons
Art Unit	2879
Examiner Name	Joseph L. Williams
Attorney Docket Number	NOR-951A

Please change the Correspondence Address for the above-identified patent application to:

[X] Customer Number : 37172

OR

[ ] Firm or Individual Name					
Address					
Address					
City		State		Zip	
Country					
Telephone		Fax			

This form cannot be used to change the data associated with a Customer Number. To change the data associated with an existing Customer Number use "Request for Customer Number Data Change" (PTO/SB/124).

I am the:

[ ] Applicant/Inventor

[ ] Assignee of record of the entire interest.
Statement under 37 CFR 3.73(b) is enclosed. (Form PTO/SB/96).

[X] Attorney or Agent of record. Registration Number 40,532

[ ] Registered practitioner named in the application transmittal letter in an application without an executed oath or declaration. See 37 CFR 1.33(a)(1). Registration Number ________

Typed or Printed Name	David H. Brinkman		
Signature			
Date	8/16/04	Telephone	(513) 241-2324

NOTE: Signatures of all the inventors or assignees of record of the entire interest or their representative(s) are required. Submit multiple forms if more than one signature is required, see below*.

[X] *Total of 1 forms are submitted.

This collection of information is required by 37 CFR 1.33. The information is required to obtain or retain a benefit by the public which is to file (and by the USPTO to process) an application. Confidentiality is governed by 35 U.S.C. 122 and 37 CFR 1.14. This collection is estimated to take 3 minutes to complete, including gathering, preparing, and submitting the completed application form to the USPTO. Time will vary depending upon the individual case. Any comments on the amount of time you require to complete this form and/or suggestions for reducing this burden, should be sent to the Chief Information Officer, U.S. Patent and Trademark Office, U.S. Department of Commerce, P.O. Box 1450, Alexandria, VA 22313-1450. DO NOT SEND FEES OR COMPLETED FORMS TO THIS ADDRESS. SEND TO: Commissioner for Patents, P.O. Box 1450, Alexandria, VA 22313-1450.

If you need assistance in completing the form, call 1-800-PTO-9199 and select option 2.

10/088464

APPARATUS AND METHOD FOR GENERATING ULTRAVIOLET RADIATION

Cross-Reference

The present application claims the filing benefit of provisional application U.S. Serial No. 60/155,028 filed September 20, 1999, the disclosure of which is hereby incorporated herein by reference in its entirety.

Field of the Invention

The present invention relates generally to ultraviolet radiation generators and, more particularly, to a method and apparatus for generating ultraviolet radiation through excitation of a plasma bulb mounted within a microwave chamber.

Background of the Invention

Ultraviolet radiation generators are known for coupling microwave energy to an electrodeless lamp, such as an ultraviolet (UV) plasma bulb mounted within a microwave chamber of an ultraviolet lamp system. In ultraviolet lamp drying (heating) and curing applications, one or more magnetrons are typically provided in the lamp system to couple microwave radiation to the plasma bulb mounted within the microwave chamber. The magnetrons are coupled to the microwave chamber through one or more waveguides that include output ports connected to an upper end of the chamber. The microwave chamber has coupling slots or antennas positioned at or near the outlet ports of the waveguides for coupling the microwave radiation to the plasma bulb. When the plasma

bulb is sufficiently excited by the microwave energy, it emits ultraviolet radiation through a bottom end of the microwave chamber toward a substrate to be irradiated. While the coupling slots or antennas are capable of coupling the microwave energy into the microwave chamber, they have a known drawback of creating fringe energy fields that form potentially damaging regions of concentrated microwave energy near the ends of the bulb. The fringe energy fields generated in the vicinity of the coupling structures act aggressively with the plasma bulb to cause local heating of the bulb envelope near the ends of the bulb. This localized heating of the bulb envelope generally shortens the bulb's operating life.

Typically, the microwave chamber of the UV lamp system includes a mesh screen mounted to the bottom end of the chamber that is transmissive to ultraviolet radiation but is opaque to microwaves. UV lamp systems used in curing of adhesives, sealants or coatings, for example, typically include a reflector mounted within the microwave chamber that is operable to focus the emitted ultraviolet radiation in a predetermined pattern toward the substrate to be irradiated. The reflector may be metallic and form part of the microwave chamber or, alternatively, may comprise a coated glass reflector mounted within the chamber. It will be appreciated that the terms "upper end" and "bottom end" are used herein to simplify description of the microwave chamber in connection with the orientation of the chamber as shown in the figures. Of course, the orientation of the microwave chamber may change depending on the particular ultraviolet

lamp drying (heating) or curing application without altering the structure or function of the microwave chamber in any way.

In UV lamp systems, the efficiency and reliability of the plasma bulb is affected by the uniformity of the microwave field created in the microwave chamber. If regions of the plasma within the bulb are not sufficiently excited by microwave energy, localized areas of minimal ultraviolet radiation may be formed along the longitudinal axis of the plasma bulb, thereby providing a generally non-uniform light output from the plasma bulb. On the other hand, if regions of high local fields are generated in the bulb, such as created by coupling structures formed in the path of the propagating microwave energy, local heating of the bulb envelope may occur that results in shorter bulb life and a reduction in bulb performance and reliability.

Accordingly, there is a need for an ultraviolet radiation generator that couples microwave energy to a plasma bulb in a controlled and efficient manner. There is also a need for an ultraviolet radiation generator that improves the light output uniformity of the plasma bulb along its longitudinal length. There is yet also a need for an ultraviolet radiation generator that improves bulb life by reducing the occurrence of potentially damaging high local fields along the length of the plasma bulb.

Summary of the Invention

The present invention overcomes the foregoing and other shortcomings and drawbacks of ultraviolet radiation generators and methods for generating ultraviolet radiation heretofore known. While the

invention will be described in connection with certain embodiments, it will be understood that the invention is not limited to these embodiments. On the contrary, the invention includes all alternatives, modifications and equivalents as may be included within the spirit and scope of the present invention.

An ultraviolet radiation generator or light source in accordance with a preferred embodiment of the present invention includes a pair of microwave generators or magnetrons that are directly coupled through waveguides to a longitudinally extending microwave chamber. Microwave energy is "dumped", i.e., directly coupled without restriction, into the microwave chamber without the use of coupling slots, antennas or other coupling structures. The direct "dumping" of the microwave energy into the microwave chamber enhances the starting ability of the light source as well as reducing the formation of potentially damaging zones of concentrated microwave energy near the ends of the plasma bulb.

The microwave chamber is capable of supporting standing microwave energy waves generated by the pair of magnetrons along its longitudinal length. A longitudinally extending electrodeless plasma bulb is mounted within the microwave chamber and is operable to emit ultraviolet radiation from the chamber in response to excitation of the bulb by the microwave energy generated by the pair of magnetrons. A glass reflector is mounted within the microwave chamber and is configured to reflect ultraviolet radiation emitted from the plasma bulb toward a substrate to be irradiated.

The microwave chamber includes a pair of end walls, a pair of side walls extending longitudinally between the pair of end walls, and a top wall. In accordance with the principles of the present invention, the microwave chamber further includes a pair of longitudinally extending tuning walls positioned on opposite sides of the plasma bulb that extend inwardly and upwardly from the side walls toward the top wall. The inward tilting of the tuning walls effectively narrows the side walls of the microwave chamber adjacent the plasma bulb to cause overlapping of the standing microwave energy waves within the chamber generally along the longitudinal length of the plasma bulb. By altering the inward tilting of the tuning walls, or by altering the horizontal and vertical extents of the tuning walls, the extent of overlapping of the standing microwave energy waves may be adjusted within the microwave chamber. Further, by varying the length of the waveguides, the impedance matching between the magnetrons and the microwave chamber can be adjusted so that an optimum amount of microwave energy generated by the magnetrons is absorbed by the plasma bulb.

The tuning walls of the microwave chamber cause "hot zones" produced by one of the magnetrons to be phase shifted with respect to "hot zones" produced by the other magnetron to prevent direct overlapping of the respective "hot zones" produced by the pair of magnetrons which may otherwise damage the plasma bulb. To improve bulb performance, the respective "hot zones" produced by the pair of magnetrons are generally spaced along the length of the bulb so that the bulb is generally uniformly

excited along its length. In accordance with a preferred embodiment of the present invention, the "hot zones" of one magnetron are generally superimposed with "cool zones" produced by the other magnetron to produce a resulting series of generally uniform "energy zones" spaced along the length of the plasma bulb.

The above and other objects and advantages of the present invention shall be made apparent from the accompanying drawings and the description thereof.

Brief Description of the Drawings

The accompanying drawings, which are incorporated in and constitute a part of this specification, illustrate embodiments of the invention and, together with a general description of the invention given above, and the detailed description of the embodiments given below, serve to explain the principles of the invention.

Fig. 1 is a perspective view of an ultraviolet radiation generator in accordance with the principles of the present invention;

Fig. 2 is a cross-sectional view of the ultraviolet radiation generator taken along line 2-2 of Fig. 1; and

Fig. 2A is a partial cross-sectional view similar to Fig. 2 illustrating an ultraviolet radiation generator in accordance with an alternative embodiment of the present invention;

Fig. 3A is a diagrammatic view illustrating an energy distribution pattern generated along the longitudinal length of a plasma bulb as generated by only one of a pair of magnetrons;

Fig. 3B is a diagrammatic view illustrating an energy distribution pattern generated along the longitudinal length of the plasma bulb by only the other of the pair of magnetrons; and

Fig. 3C is a diagrammatic view illustrating an energy distribution pattern generated along the longitudinal length of the plasma bulb by both magnetrons operating simultaneously.

Detailed Description of the Preferred Embodiment

With reference to the figures, an ultraviolet ("UV") radiation generator or light source 10 is shown in accordance with the principles of the present invention. Light source 10 includes a pair of microwave generators, illustrated as a pair of magnetrons 12, that are each coupled to a longitudinally extending microwave chamber 14 through a respective waveguide 16. Each waveguide 16 has an outlet port 18 coupled to an upper end of the microwave chamber 14 so that microwaves generated by the pair of microwave generators 12 are directly coupled to the microwave chamber 14 in spaced longitudinal relationship adjacent opposite upper ends of the chamber 14. The microwave energy conduit defined by each waveguide 16 is unrestricted at its entry into the microwave chamber 14 so that the microwaves are "dumped", i.e., directly coupled without restriction, into the chamber 14 without the use of coupling slots, antennas or other coupling structures.

An electrodeless plasma bulb 20, in the form of a sealed, longitudinally extending plasma bulb, is mechanically mounted within

the microwave chamber 14 and supported adjacent the upper end of the chamber 14 as is well known in the art. While not shown, it will be appreciated that light source 10 is mechanically mounted within a cabinet or housing well known to those of ordinary skill in the art that includes the necessary pressurized cooling air and electrical connections for operation of the light source 10. As will be described in greater detail below, light source 10 is designed and constructed to emit ultraviolet radiation, illustrated diagrammatically at 24 (Fig. 2) from a bottom end of the microwave chamber 14 upon sufficient excitation of the plasma bulb 20 by microwave energy coupled to the microwave chamber 14 from the pair of microwave generators 12.

More particularly, light source 10 includes a starter bulb 26, and a pair of transformers 28 that are each electrically coupled to a respective one of the magnetrons 12 to energize filaments of the magnetrons 12 as understood by those skilled in the art. The magnetrons 12 are mechanically mounted to inlet ports 30 of the waveguides 16 so that microwaves generated by the magnetrons 12 are discharged into the chamber 14 through the longitudinally spaced apart outlet ports 18 of the waveguides 16. Preferably, the frequencies of the two magnetrons 12 are split or offset by a small amount to prevent intercoupling between them during operation of the light source 10. For example, magnetrons 12 may each have an output power rating of about 3KWatt, with one of the magnetrons 12 operating at a frequency of about 2443 MHz and the other magnetron

12 operating at a frequency of about 2465 MHz. Of course, other magnetron output power ratings and operating frequencies are possible without departing from the spirit and scope of the present invention.

In one embodiment of the present invention, microwave chamber 14 is constructed generally as a rectangular chamber for supporting standing microwave energy waves along its longitudinal length. Thus, according to the principles of the present invention, the standing microwave energy waves generated by the pair of magnetrons 12 within the microwave chamber 14 are generally aligned along the longitudinal length of the plasma bulb 20 to thereby create a resulting microwave energy field that generally uniformly excites the bulb 20 along its length as will be described in more detail below in connection with Figs. 3A-3C.

As best understood with reference to Figs. 1 and 2, microwave chamber 14 includes a generally horizontal top wall 32, a pair of generally vertical opposite end walls 34, and a pair of generally vertical opposite side walls 36 that extend longitudinally between the end walls 34 and on opposite sides of the plasma bulb 20. Two (2) pairs of generally vertical inner walls 38 are spaced from and parallel to the end walls 34. The end walls 34, side walls 36 and inner walls 38 form a pair of openings 40 at an upper end of the microwave chamber 14 that are aligned with and directly coupled to the outlet ports 18 of the waveguides 16. Each opening 40 has a cross-sectional area that is substantially equal to the cross-sectional area of each outlet port 18.

In this way, the microwave energy generated by each magnetron 12 is "dumped", i.e., directly coupled without restriction, to the microwave chamber 14 without the use of coupling slots, antennas or other coupling structures. In this way, the direct "dumping" of the microwave energy into the microwave chamber 14 enhances the starting ability of the light source 10 as well as reducing the formation of potentially damaging zones of concentrated microwave energy near the ends of the plasma bulb 20 that may damage the bulb. While not shown, it is contemplated in an alternative embodiment of the present invention that the outlet ports 18 of the waveguides 16 may enter the microwave chamber 14 through the opposite end walls 34 of the chamber 14 without departing from the spirit or scope of the present invention.

Microwave chamber 14 further includes a pair of longitudinally extending, generally planar tuning walls 42 that extend upwardly and inwardly from the side walls 36 toward the top wall 32, and are positioned between the opposite pairs of the vertical inner walls 38. In this way, the tuning walls 42 are positioned between the openings 40 of the microwave chamber 14 and on opposite sides of the plasma bulb 20 to effectively narrow the side walls 36 of the chamber 14 adjacent the plasma bulb 20. By narrowing the side walls 36 adjacent the bulb 20, the tuning walls 42 operate to overlap or superimpose the respective standing waves generated by the pair of magnetrons 12 as described in detail below. Alternatively, as shown in

Fig. 2A, each of the tuning walls on opposite sides of the plasma bulb 20 may comprise multiple wall segments 42a and 42b that tilt inwardly from the side walls 36 toward the top wall 32 to effectively narrow the side walls 36 of chamber 14 adjacent the plasma bulb 20. While not shown, it is contemplated in yet another alternative embodiment of the present invention that the tuning walls could be curved to extend inwardly from the side walls 36 toward the top wall 32 to provide the desired effective narrowing of the microwave chamber 14 adjacent opposite sides of the plasma bulb 20.

In one embodiment of the present invention, as shown in Figs. 1 and 2, the microwave chamber 14 has a longitudinal length of about 10", a width of about 4.21" and a height of about 3.50". The tuning walls 42 tilt inwardly from the side walls 36 at an angle "α" (Fig. 2) of about 60° relative to a plane 44 generally perpendicular to the side walls 36, although other dimensions of the chamber 14 and angles "α" of the tuning walls 42 are possible without departing from the spirit and scope of the present invention. By altering the inward angle "α" of the tuning walls 42, or by altering the horizontal and vertical extents of the tuning walls 42, the extent of overlapping of the standing energy waves generated by the pair of magnetrons 12 may be adjusted within the microwave chamber 14 as described in detail below.

Still referring to Figs. 1 and 2, the light source 10 includes an elliptical glass reflector 46 mounted within the microwave chamber 14 through longitudinally spaced apart retainers 48, and has its lower

end supported on generally horizontal, inwardly directed flanges 50 of the light source 10. It will be appreciated that other cross-sectional configurations of reflector 46 are possible for varying the reflected radiation pattern without departing from the spirit and scope of the present invention. Reflector 46 is transparent to the microwave energy generated by the magnetrons 12 and reflects ultraviolet radiation 24 emitted from the plasma bulb 20 toward a substrate (not shown) to be irradiated as will be appreciated by those skilled in the art. A mesh screen 54 is mounted to the bottom end of the microwave chamber 14 that is transparent to the emitted ultraviolet radiation 24 while remaining opaque to the generated microwaves. The waveguides 16 and microwave chamber 14 are welded or otherwise connected together to form an integral unit for supporting the starter bulb 26, filament transformers 28 and magnetrons 12. The waveguides 16, top wall 32, end walls 34, side walls 36, inner walls 38 and tuning walls 42 are metallic and serve as reflectors to the microwave energy coupled to microwave chamber 14 by the magnetrons 12. As illustrated in the figures, each of the waveguides 16, top wall 32, end walls 34, side walls 36 and tuning walls 42 includes apertures 58 to permit cooling air to be passed through the light source 10.

In operation, it is desirous to obtain a generally uniform microwave energy field along the longitudinal length of the plasma bulb 20. When a standing wave pattern is generated within the microwave chamber 14, the plasma bulb 20 is subjected to concentrated

microwave energy fields that are longitudinally spaced along the length of the plasma bulb 20. These concentrated microwave energy fields generally coincide with the regions of maximum amplitude (i.e., antinodes) of the standing waves. In those regions of concentrated microwave energy, a resultant concentration of plasma or "hot zone" will be created within the plasma bulb 20, while in the non-concentrated microwave energy regions, "cold zones" within the plasma bulb 20 will result. The "cold zones" generally coincide with the nodes of the standing waves. The alternating "hot zones" and "cool zones" within the plasma bulb 20 may cause non-uniform light output along the axis of the plasma bulb 20 and local heating of the bulb envelope, thereby resulting in shorter bulb life and a reduction in bulb performance and reliability.

As shown diagrammatically in Fig. 3A-3C, the microwave chamber 14 of present invention takes advantage of the standing microwave energy fields generated by the pair of magnetrons 12 to provide a generally uniform energy field along the axis of the plasma bulb 20. More particularly, the narrowing of the side walls 36 of the microwave chamber 14 through inward tilting of the tuning walls 42 causes overlapping or superimposing of the respective standing waves generated by the pair of magnetrons 12 so that the "hot zones" produced by one of the magnetrons 12 are preferably phase shifted with respect to the "hot zones" produced by the other magnetron to prevent direct overlapping of the respective "hot zones" produced by

the pair of magnetrons 12 which may otherwise damage the bulb 20. To improve bulb performance, the respective "hot zones" produced by the pair of magnetrons are generally spaced along the length of the bulb 20 so that the bulb is generally uniformly excited along its length.

In accordance with a preferred embodiment of the present invention as shown in Figs. 3A-3C, the "hot zones" of one magnetron 12 are generally superimposed with the "cool zones" produced by the other magnetron 12 to produce a resulting series of generally uniform "energy zones" spaced along the length of the bulb 20. That is, the antinodes of the standing wave generated by one of the magnetrons 12 is generally superimposed with the node of the standing wave generated by the other magnetron 12. Of course, other phase relationships of the "hot" and "cold" zones produced by the pair of magnetrons 12 are possible without departing from the spirit and scope of the present invention. Most importantly, however, the microwave chamber 14 is constructed so that the antinodes of the standing waves are prevented from directly superimposing themselves on each other, thereby causing undesirable "hot zones" of generally double microwave energy in localized areas of the plasma bulb 20 that may damage the bulb.

As shown in Fig. 3A, the microwave energy field produced by only a first of the magnetrons 12 in operation produces alternating "hot zones ("H_1")" and "cool zones ("L_1")" along the length of the bulb 20 that correspond generally with the antinodes and nodes,

respectively, of the standing wave generated by the single first magnetron 12. Likewise, as shown in Fig. 3B, the microwave energy field produced by only the second magnetron 12 in operation produces alternating "cool zones ("L_2")" and "hot zones ("H_2")" along the length of the bulb 20 that correspond generally with the nodes and antinodes, respectively, of the standing wave generated by the single second magnetron 12.

With both of the magnetrons 12 powered and in operation, as shown in Fig. 3C, the microwave chamber 14 is pre-tuned by the inwardly tilting tuning walls 42 to cause the "hot zones ("H_1")" of the first magnetron 12 to be generally superimposed with the "cool zones ("L_2")" of the second magnetron 12, and to cause the "hot zones ("H_2")" of the second magnetron 12 to be generally superimposed with the "cool zones ("L1")" of the first magnetron 12. In this way, generally uniform "energy zones ("H_1/L_2" and "H_2/L_1")" are generated along the length of the bulb 20 as shown diagrammatically in Fig. 3C. It will be appreciated that by altering the angle "α" of the tuning walls 42, and/or by altering the vertical and horizontal extents of the tuning walls 42, the extent of overlapping of the standing waves generated by the pair of magnetrons 12 of the standing waves, can be adjusted to achieve generally uniform "energy zones" along the length of the plasma bulb 20. In addition, it is contemplated that the phase relationship of the standing waves can be further tuned or adjusted by varying the length of each waveguide 16. More particularly, by varying

the length of each waveguide 16, the impedance matching between the magnetrons 12 and the microwave chamber 14 can be adjusted so that an optimum amount of microwave energy generated by the magnetrons 12 is absorbed by the plasma bulb 20.

While a pair of magnetrons 12 are shown and described, it will be appreciated that more than two magnetrons may be coupled to the microwave chamber 14 without departing from the spirit and scope of the present invention. In this alternative embodiment of the present invention (not shown), the standing microwave energy wave produced by each of the magnetrons is phase shifted relative to the standing waves produced by the other magnetrons so that the "hot zones" produced by the respective magnetrons do not directly overlap each other and are generally spaced along the length of the bulb 20.

Thus, the microwave chamber 14 of the present invention couples microwave energy from the pair of magnetrons 12 to the plasma bulb 20 in a controlled and efficient manner. The microwave chamber 14 of the present invention also improves the light output uniformity of the plasma bulb 20 along its length by eliminating "cool zones" of limited plasma energy. Moreover, the microwave chamber 14 of the present invention improves bulb life and reliability by reducing the occurrence of potentially damaging "hot zones" in the bulb 20.

While the present invention has been illustrated by a description of various embodiments and while these embodiments have been described in considerable detail, it is not the intention of the

applicants to restrict or in any way limit the scope of the appended claims to such detail. Additional advantages and modifications will readily appear to those skilled in the art. The invention in its broader aspects is therefore not limited to the specific details, representative apparatus and method, and illustrative example shown and described. Accordingly, departures may be made from such details without departing from the spirit or scope of applicants' general inventive concept.

Having described the invention, WE CLAIM:

1. An apparatus for generating ultraviolet radiation, comprising:

a longitudinally extending microwave chamber capable of supporting standing microwave energy waves therein;

a longitudinally extending plasma bulb mounted within said microwave chamber; and

a pair of microwave generators coupled to said microwave chamber and capable of generating a pair of standing microwave energy waves within said chamber for exciting said plasma bulb to emit ultraviolet radiation from said chamber.

2. The apparatus of claim 1 further comprising a pair of longitudinally extending tuning walls positioned on opposite sides of said plasma bulb and capable of overlapping said pair of standing microwave energy waves within said chamber generally along the longitudinal length of said plasma bulb.

3. The apparatus of claim 2, wherein said microwave chamber comprises:

a pair of end walls;

a pair of side walls extending longitudinally between said pair of end walls;

a top wall; and

said pair of tuning walls extending inwardly and upwardly from said pair of side walls toward said top wall.

4. The apparatus of claim 3, wherein each of said tuning walls comprises a generally planar wall extending inwardly and upwardly from one of said side walls toward said top wall.

5. The apparatus of claim 3, wherein each of said tuning walls comprises at least two generally planar walls extending inwardly and upwardly from one of said side walls toward said top wall.

6. The apparatus of claim 1 further comprising:

a longitudinally extending, microwave transparent reflector mounted within said microwave chamber and capable of reflecting ultraviolet radiation emitted by said plasma bulb; and

a pair of waveguides directly coupling said pair of magnetrons to said microwave chamber, said microwave chamber having a pair of openings formed therein and each of said waveguides having an outlet port communicating directly with one of said openings in said microwave chamber.

7. The apparatus of claim 6 wherein each of said openings has a cross-sectional area that is substantially equal to a cross-sectional area of one of said outlet ports.

8. The apparatus of claim 6 further comprising a pair of longitudinally extending tuning walls positioned on opposite sides of said plasma bulb and capable of overlapping said pair of standing microwave energy waves within said chamber generally along the longitudinal length of said plasma bulb.

9. The apparatus of claim 8, wherein said microwave chamber comprises:

a pair of end walls;

a pair of side walls extending longitudinally between said pair of end walls;

a top wall; and

said pair of tuning walls extending inwardly and upwardly from said pair of side walls toward said top wall.

10. The apparatus of claim 9, wherein each of said tuning walls comprises a generally planar wall extending inwardly and upwardly from one of said side walls toward said top wall.

11. The apparatus of claim 9, wherein each of said tuning walls comprises at least two generally planar walls extending inwardly and upwardly from one of said side walls toward said top wall.

12. An apparatus for generating ultraviolet radiation, comprising:

a longitudinally extending microwave chamber;

a longitudinally extending plasma bulb mounted within said microwave chamber;

a pair of microwave generators coupled to said microwave chamber and capable of generating microwave energy waves within said chamber for exciting said plasma bulb to emit ultraviolet radiation from said chamber; and

a pair of longitudinally extending tuning walls positioned on opposite sides of said plasma bulb and capable of tuning said microwave chamber to optimize coupling of said microwave energy waves to said plasma bulb.

13. The apparatus of claim 12, wherein said microwave chamber comprises:

a pair of end walls;

a pair of side walls extending longitudinally between said pair of end walls;

a top wall; and

said pair of tuning walls extending inwardly and upwardly from said pair of side walls toward said top wall.

14. The apparatus of claim 13, wherein each of said tuning walls comprises a generally planar wall extending inwardly and upwardly from one of said side walls toward said top wall.

15. The apparatus of claim 13, wherein each of said tuning walls comprises at least two generally planar walls extending inwardly and upwardly from one of said side walls toward said top wall.

16. The apparatus of claim 12 further comprising:

a longitudinally extending, microwave transparent reflector mounted within said microwave chamber and capable of reflecting ultraviolet radiation emitted by said plasma bulb; and

a pair of waveguides directly coupling said pair of magnetrons to said microwave chamber, said microwave chamber having a pair of openings formed therein and each of said waveguides having an outlet port communicating directly with one of said openings in said microwave chamber.

17. The apparatus of claim 16 wherein each of said openings has a cross-sectional area that is substantially equal to a cross-sectional area of one of said outlet ports.

18. The apparatus of claim 16, wherein said microwave chamber comprises:

a pair of end walls;

a pair of side walls extending longitudinally between said pair of end walls;

a top wall; and

said pair of tuning walls extending inwardly and upwardly from said pair of side walls toward said top wall.

19. The apparatus of claim 18, wherein each of said tuning walls comprises a generally planar wall extending inwardly and upwardly from one of said side walls toward said top wall.

20. The apparatus of claim 18, wherein each of said tuning walls comprises at least two generally planar walls extending inwardly and upwardly from one of said side walls toward said top wall.

21. A method for generating ultraviolet radiation from a plasma bulb mounted longitudinally within a microwave chamber, comprising:

generating microwave energy waves from at least two sources; and

coupling the microwave energy waves into the microwave chamber creating standing microwave energy waves longitudinally within the microwave chamber that excite the plasma bulb to emit ultraviolet radiation from the chamber.

22. The method of claim 21, wherein said step of coupling further comprises directly coupling the microwave energy waves into the microwave chamber.

23. The method of claim 22, further comprising the step of overlapping the standing microwave energy waves within the chamber generally along the longitudinal length of the plasma bulb.

24. The method of claim 22, further comprising the step of adjusting the phase relationship of the standing microwave energy waves within the microwave chamber.

25. The method of claim 23, further comprising the step of adjusting the phase relationship of the standing microwave energy waves within the microwave chamber.

26. The method of claim 21, further comprising the step of overlapping the standing microwave energy waves within the chamber generally along the longitudinal length of the plasma bulb.

27. The method of claim 26, further comprising the step of adjusting the phase relationship of the standing microwave energy waves within the microwave chamber.

28. The method of claim 21, further comprising the step of adjusting the phase relationship of the standing microwave energy waves within the microwave chamber.

29. A method for generating ultraviolet radiation from a plasma bulb mounted longitudinally within a microwave chamber, comprising:

generating microwave energy waves from at least two sources; and

directly coupling the microwave energy waves into the microwave chamber for creating microwave energy waves longitudinally within the microwave chamber that excite the plasma bulb to emit ultraviolet radiation from the chamber.

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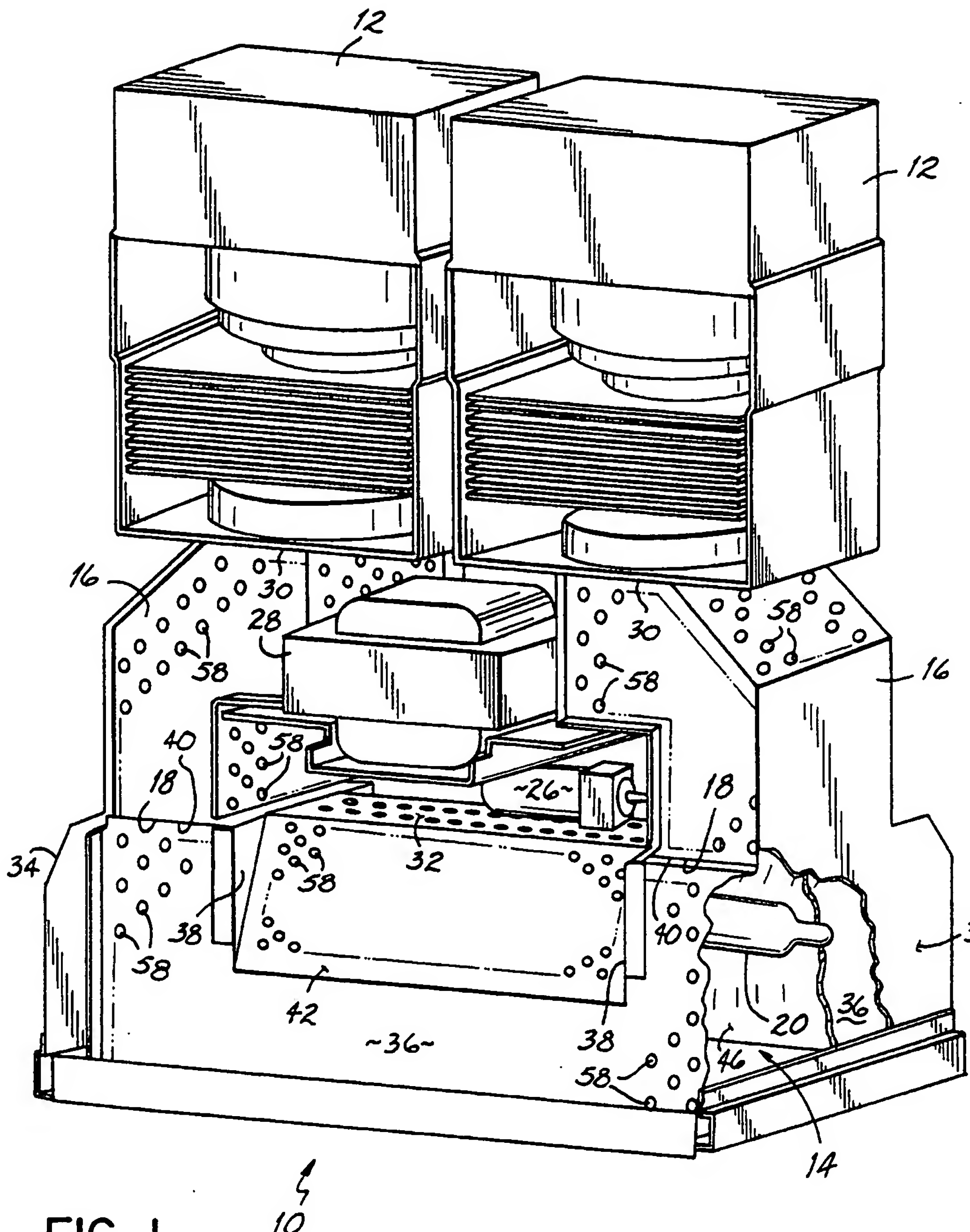

FIG. 1

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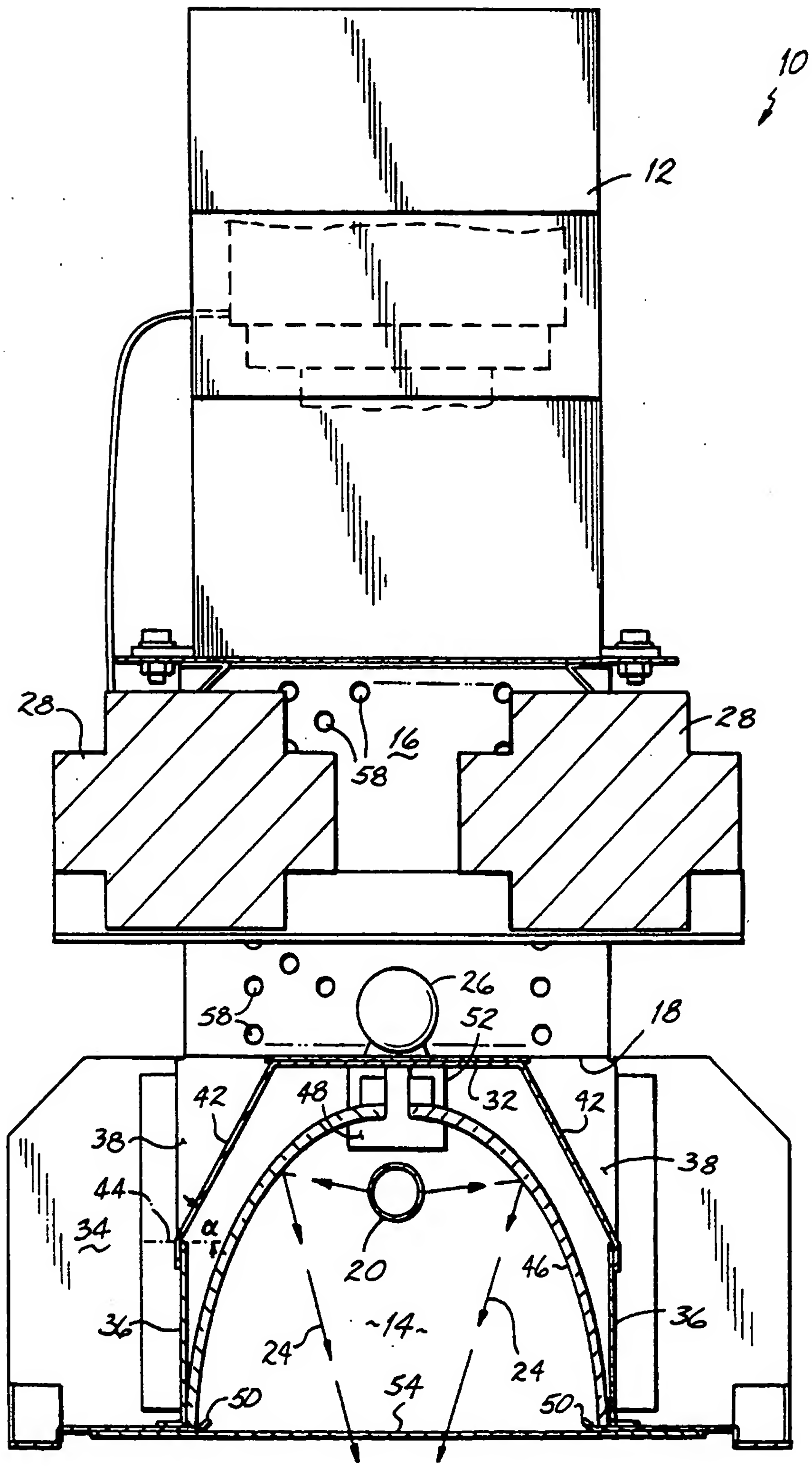

FIG. 2

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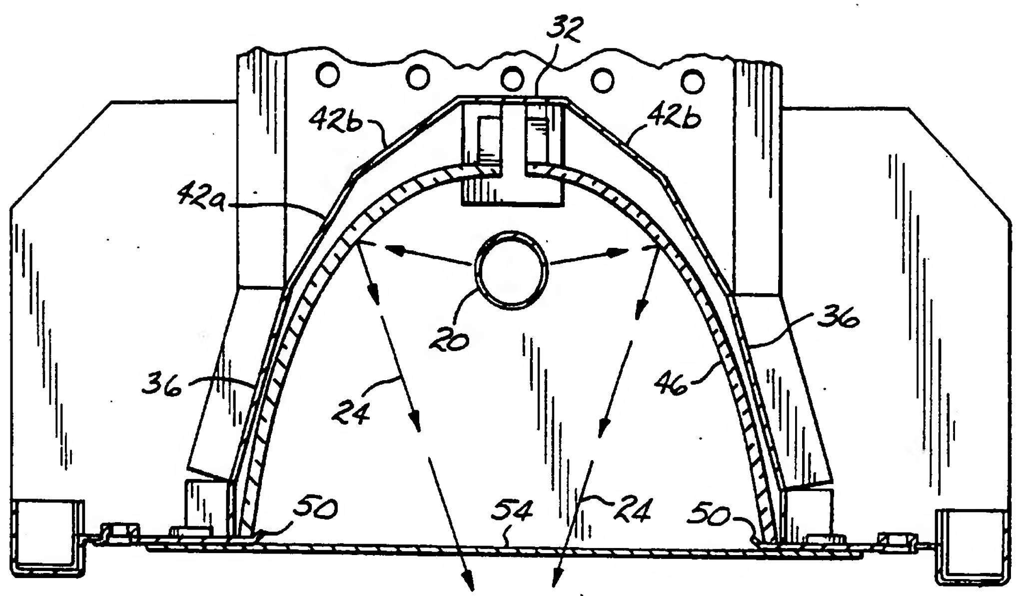

FIG. 2A

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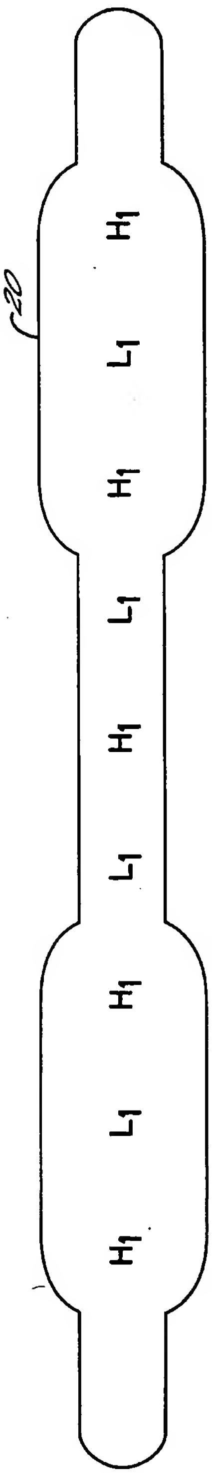

FIG. 3A

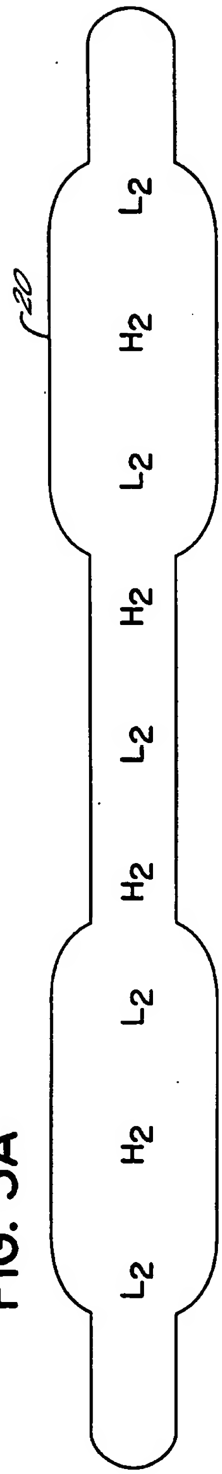

FIG. 3B

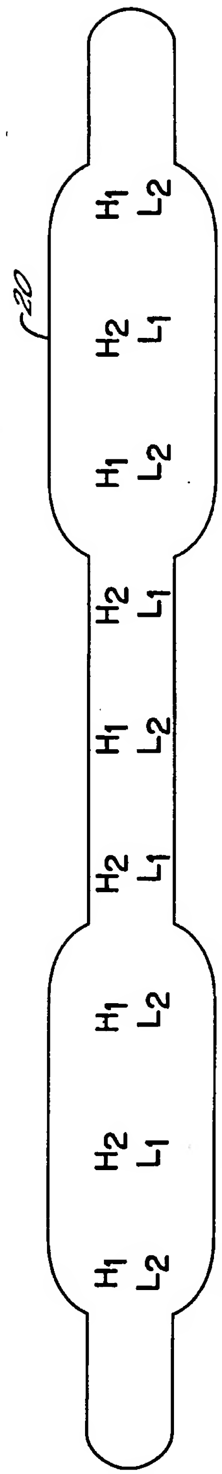

FIG. 3C

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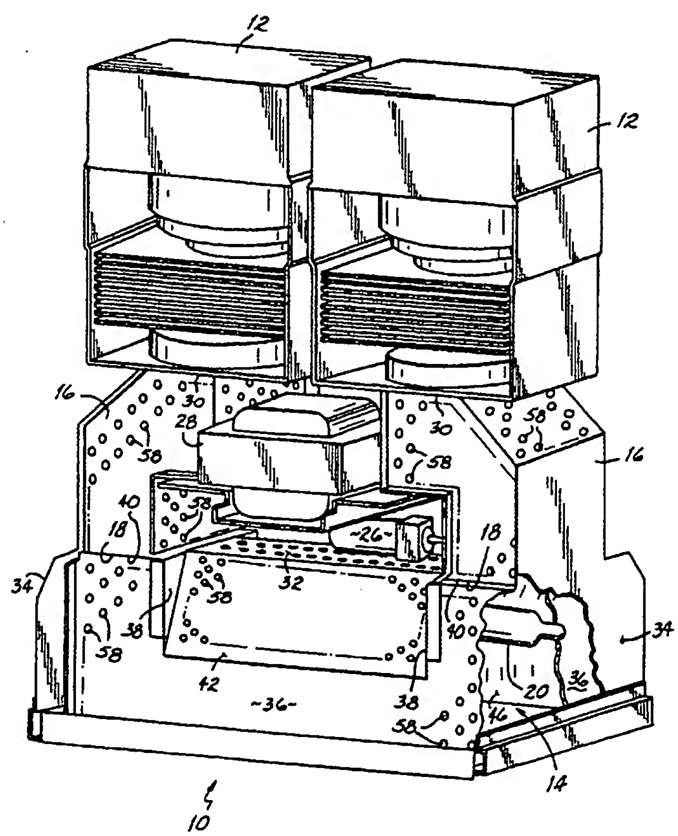
[Continued on next page]

(54) Title: APPARATUS AND METHOD FOR GENERATING ULTRAVIOLET RADIATION



(57) Abstract: An apparatus (10) for generating ultraviolet radiation includes a pair of magnetrons (12) coupled to a longitudinally extending microwave chamber (14) for generating standing microwave energy waves within the chamber (14). Microwave energy from the magnetrons (12) is directly coupled to the microwave chamber (14) without the use of coupling slots, antennas or other coupling structures. A longitudinally extending electrodeless plasma bulb (20) is mounted within the microwave chamber (14) and is operable to emit ultraviolet radiation (24) in response to excitation by the microwave energy generated by the pair of magnetrons (12). The microwave chamber (14) includes a pair of longitudinally extending tuning walls (42) positioned on opposite sides of the plasma lamp bulb (20) and capable of overlapping the standing microwave energy waves generally along the longitudinal length of the plasma bulb (20).

WO 01/22783 A2

patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

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In re Application of	:	
SCHMITKONS, James, W., et al.	:	
U.S. Application No.:10/088,464	:	DECISION
PCT No.: PCT/US00/25282	:	
International Filing Date: 15 September 2000	:	
Priority Date: 20 September 1999	:	
Attorney's Docket No.: NOR-951A	:	
For: APPARATUS AND METHOD FOR GENERATING ULTRAVIOLET RADIATION	:	

This decision is in response to the "Request For Corrected Filing Receipt" filed 10 June 2002 and resubmitted on 05 September 2003. Included in the submission is a request to correct the 35 U.S.C. 371 date from 18 March 2002 to 19 March 2002, the date on which the application materials were purportedly deposited as "Express Mail" with the USPS. The filing date portion of the present submission is treated herein as a petition under 37 CFR 1.10. No petition fee is required.

BACKGROUND

On 21 May 2002, the DO/EO/US mailed in the above-captioned application a "Notification Of Acceptance Of Application Under 35 U.S.C. 371 And 37 CFR 1.494 Or 1.495" identifying 18 March 2002 as the "Date Of Receipt Of 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) Requirements" and the "Date Of Receipt Of All 35 U.S.C. Requirements."

On 24 May 2002, the USPTO issued applicant a filing receipt identifying 19 March 2002 as the filing date. The filing receipt also indicated that the application included 2 sheets of drawings and 11 claims.

On 10 June 2002, applicant filed the submission considered herein (the materials were resubmitted on 05 September 2003). As noted above, the submission seeks, in part, to correct the 18 March 2002 filing date assigned to this application.

On 01 October 2003, an Office Action was mailed by this Office which addressed an application containing 11 claims.

DISCUSSION

A review of the present submission and the USPTO's "Express Mail" database confirms that the national stage application materials here were deposited with the USPS as "Express Mail" on 19 March 2002. Accordingly, the 35 U.S.C. 371 date herein is appropriately corrected to 19 March 2002. The Notification Of Acceptance mailed 21 May 2002 and the filing receipt mailed on 24 May 2002, both of which contain the incorrect 18 March 2002 date, are therefore appropriately vacated.

With respect to the number of claims and drawings, a review of the application file confirms applicants' assertion that the present application contains four pages of drawings and 29 claims. Accordingly, these corrections will be incorporated into the revised filing receipt.

Finally, it appears that the Office Action mailed 01 October 2003 was based on an examination of a different specification from the specification of record herein (one of the references accompanying the Information Disclosure Sheet was substituted for the specification of PCT/US00/25282 in the "Application As Filed" section of the application file). Accordingly, the Office Action is appropriately vacated.

CONCLUSION

Applicant's petition under 37 CFR 1.10 is **GRANTED**. The 35 U.S.C. 371 date for this application is corrected to 19 March 2002.

The "Notification Of Acceptance Of Application Under 35 U.S.C. 371 And 37 CFR 1.494 Or 1.495" mailed 21 May 2002, the filing receipt mailed 24 May 2002, and the Office Action mailed 01 October 2003, are hereby **VACATED**.

The application is being forwarded to the National Stage Processing Branch of the Office Of PCT Operations for further processing in accord with this decision, including: (1) mailing a corrected Notification Of Acceptance identifying **19 March 2002** as the "Date Of Receipt Of 35 U.S.C. 371(c)(1), (c)(2) and (c)(4) Requirements" and the "Date Of Receipt Of All 35 U.S.C. Requirements;" and (2) issuing a corrected filing receipt identifying **19 March 2002** as the filing date, and indicating that the application includes four pages of drawings and 29 claims; and (3) returning the application to Group Art Unit 2879 for examination of the correct specification..

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PATENT

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Serial No.:	10/088,464
Filed:	March 19, 2002
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Sir:

REQUEST FOR CORRECTED FILING RECEIPT

Attached is a copy of the Official Filing Receipt received from the PTO in the above-identified application for which issuance of a corrected filing receipt is respectfully requested.

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(54) Title of the Invention:

PROCESS FOR GENERATING ULTRAVIOLET RADIATION FROM A MICROWAVE SOURCE AND DEVICE FOR IMPLEMENTING THIS PROCESS

(57) Abstract:

The invention concerns a process for generating ultraviolet radiation from a microwave source and an electrodeless tube *9* placed in a cavity *8* excited by means of a microwave generator *1* and resonated at an appropriate mode, and is characterized by the fact that it consists in orienting the polarized stationary electric field *E* of constant amplitude parallel to the axis of the discharge tube *9*, and in overdimensioning the cavity so that this tube has its longitudinal dimension along a resonance antinode of the mode excited in the cavity.

PROCESS FOR GENERATING ULTRAVIOLET RADIATION FROM A MICROWAVE SOURCE AND DEVICE FOR IMPLEMENTING THIS PROCESS

The present invention concerns a process and a device for generating intense light radiation in the ultraviolet region, applicable in particular in the treatment of industrial products coated with a layer of ink or varnish or with a photosensitive product, in order to achieve homogeneous and uniform drying, or else for specific applications in the areas of industrial photosynthesis, surface treatments, photochemical reactions, etc.

Processes are already known which make it possible to produce ultraviolet radiation from discharge lamps equipped with electrodes connected to an appropriate source of voltage, creating ionization and intense light emission in the gas atmosphere of the lamp. These lamps are nonetheless not very practical to use, requiring very high starting voltages, and do not make it possible to obtain completely homogeneous ultraviolet radiation over a sufficient surface area for the applications in question.

Systems are also known which use a tube of a gas atmosphere sealed under a suitable pressure and without electrodes, in which the emission of an ultraviolet radiation is achieved thanks to a high-frequency electric field of constant amplitude, generated along a predetermined direction through the lamp,

whereby this field is produced from a suitable microwave source coupled to a cavity or chamber adapted for this purpose, inside which the tube is located.

But in order to obtain a homogeneous emission of ultraviolet rays over a sufficient dimension inside the tube, and in particular along the entire length of the tube, which may be as much as 20 cm or more, so that the light flux obtained hits the product to be treated along a uniform strip or region whose relative movement by moving the product creates a continuous and regular treatment over the entire surface of this latter, the electric field must be distributed in the tube by means of a traveling wave at constant amplitude, but with an intensity which is also sufficient to induce the required discharge and maintain it.

U.S. Patents No. 3,872,349 and No. 4,042,850 in the name of Fusions Systems Corporation illustrate embodiments of this type, with an electrodeless tube excited by hyperfrequency radiation, in particular between 1 and several tens of gigahertz, and preferably equal to 2,450 MHz, the standard frequency in industrial microwave applications.

These patents describe in detail the physical theory which makes possible the production of ultraviolet radiation under the effect of an electric field of constant amplitude, in which the electrons collide with the ions of the gas confined in the sealed tube, producing a suitable light emission by changing energy levels.

Nevertheless, an essential characteristic of the prior art thus represented consists in exclusively using a traveling wave through the tube, but carefully preventing any stationary wave which might result from a resonance phenomenon in the propagation of the electromagnetic wave coupled to the cavity containing this tube. In fact, in the case of such resonance with a suc-

cession of nodes and antinodes occurring along the length of the tube, with this latter positioned in the direction of the fundamental mode of the wave created, it is evident that the light energy of the ultraviolet radiation produced will mainly be emitted to the right of the areas where the electric field is maximum, thus at the antinodes, with first a decrease from these latter along the longitudinal dimension of the tube to a minimum corresponding to a node, then an increase to the next antinode, and so on. The ultraviolet radiation emitted will therefore be essentially variable along the tube length, and will not permit a homogeneous distribution over the sheet or other material to be treated, which is generally moving parallel to the tube.

To avoid such a resonance, the above-cited patents therefore specify traveling wave devices, where the hyperfrequency energy coming from appropriate emitters is coupled to the cavity and to the tube it contains by slots staggered axially and laterally, opposite to one another with respect to the direction of the discharge tube and the ends of the cavity containing it. In addition, two emitters are generally used, respectively coupled to two slots thus staggered, and their frequencies are themselves separated by a gap of about 15 MHz on either side of the average frequency of 2,450 MHz.

These known systems, widely sold today, have advantages over those using lamps with electrodes under voltage, thanks in particular to a rapid rise to temperature and to the option of almost instantaneous successive starting and extinguishing, which is particularly useful for treatments where the ultraviolet radiation must be very accurately controlled. Because of the absence of electrodes, the tube used is more luminous and can be more extensively utilized over its entire longitudinal dimension for the production of the radiation used. In addition, the simultaneous emission of infrared radiation is

reduced, thereby limiting the release of heat from the tube and noticeably increasing its useful life.

On the other hand, other drawbacks persist: in fact, these systems are limited in size and in power, since the energy supplied to the cavity and to the tube contained in it is distributed along the entire length of this tube by the traveling wave created, with definite losses overall. In addition, the coupling of the microwave energy to the tube is sometimes difficult to ensure so as to make it possible to keep a perfectly constant electric field amplitude over the entire length of the tube where the traveling wave propagates.

It is known, moreover, that in other known embodiments with a resonant structure, the propagation of an electromagnetic wave, in particular at 2,450 MHz, usually occurs in fundamental mode in a standard guide with a rectangular cross section where the short side is equal in this case to about 4.3 cm. If the electrodeless tube is placed in the axis of the guide and at its center, and if the structure is resonated, the succession of nodes and antinodes in the electric field distribution is therefore going to create, to the right of the antinodes, regions of maximum field where the emission of ultraviolet radiation will be the most intense. In these regions, the electric field component is directed in a diametral plane of the tube, perpendicular to the long sides of the guide and therefore parallel to its short sides. The result is that in this case, the ultraviolet radiation coming from the tube will be emitted over a length of only 4.3 cm, with, as described above, a succession of areas of emission and extinction along the length of the tube which are quite disadvantageous if the ultimate goal is to obtain a homogeneous distribution over an acceptable distance.

Finally, French Patent No. 82/04,398 of March 16, 1982, in the name of

the CNRS (National Center for Scientific Research) discloses a process and a device for the direct microwave treatment of sheet products, which consist in using microwave applicators in the form of elongated resonant cavities where electric field distribution is achieved with a succession of nodes and anti-nodes along the main axis of each applicator. These have a prismatic shape, in particular with a rectangular cross section, where the dimension of this cross section parallel to the electric field is adjusted to approach the TE012 mode resonance conditions, and has for this purpose a dimension at least greater than double the other side of the same cross section.

According to the information of this French patent, we thus learn that compared to a standard guide with a rectangular cross section, where the side perpendicular to the direction of the electric field is close to 8.6 cm and the side which is parallel is 4.3. cm, we can give this latter dimension a much higher value, which may be between 8 and 10 cm, and preferably is 9.1 cm. It has since been found that this same dimension can be increased up to 20 or even 25 cm, without altering the resonance conditions in the guide for the mode in question.

The object of the present invention is a process and a device which, by implementing the above specifications, avoids the limitations of traveling wave systems of the type reviewed above, making it possible, for a given energy applied to the cavity containing the electrodeless tube, to supply a higher-powered ultraviolet radiation using stationary waves in a resonant structure in accordance with the instructions of the above-mentioned French patent, with adaptation of these latter to the new application more specifically intended.

Moreover, the invention aims to provide a system where the coupling of

the hyperfrequency field to the electrodeless tube is more efficient, while making use of a simpler production technique which requires only one means for tuning the resonance frequency in the cavity receiving the tube and produces overall a more reliable, less cumbersome, and above all less expensive device than with the prior solutions, in particular the traveling wave designs.

For this purpose, the process according to the invention, using an electrodeless tube placed in a cavity excited by at least one microwave generator and resonated at an appropriate mode, is characterized by the fact that it consists in orienting the polarized stationary electric field at constant amplitude parallel to the axis of the discharge tube, and in overdimensioning the cavity so that the tube has its longitudinal dimension along a resonance antinode of the mode excited in the cavity.

The invention consists, in other words, of a new application of the process known by the above-mentioned French patent, by adapting to it the known method consisting of an electrodeless tube containing a plasma and having a flow of polarized electrons act on it, defining the electric field component of a hyperfrequency radiation supplied by a microwave generator. The collisions on the ion atoms of the gas in the tube cause the emission of light radiation, in particular in the ultraviolet region. The specified application uses an overdimensioned resonance structure, so that the tube extends along a resonance antinode and is thus excited over its entire longitudinal dimension, permitting a significant increase in the overall energy yield of the structure.

The device for implementing the process is characterized by the fact that it consists of a resonant cavity, at least one microwave emitter feeding into this cavity, a means of coupling between the cavity and the emitter, a device

for adjusting the frequency tuning of the cavity, and an electrodeless tube containing a gas at a given pressure, placed in the cavity along the direction of the electric field component for the excited mode, whereby the cavity is overdimensioned so that said component has a resonance antinode along the length of the tube.

In a first variant of the device under consideration, the cavity is prismatic and has a rectangular cross section to allow excitation of the TE012 mode of the hyperfrequency radiation, whereby the tube is placed along the zero-order direction of the mode.

In another variant, the cavity is cylindrical, with a partially elliptical cross section, whereby the tube is placed along one of the foci of the cavity. Preferably, this latter has a polished reflecting wall making it possible to focus the ultraviolet radiation emitted by the tube at the other focus of the cavity, excited on the TM010 mode of the hyperfrequency radiation.

According to another particular characteristic of the invention, the cavity has an open side parallel to the tube and consisting of a fine mesh transparent to the ultraviolet radiation emitted by the tube and opaque to the hyperfrequency radiation.

Advantageously, the device has two microwave emitters of identical or very similar frequency, with the difference in frequencies being less than the passband of the resonant cavity, so that the effects of each emitter are additive.

Also preferably, the frequency of the microwave radiation is 2,450 MHz, whereby the tube mounted in the cavity has a length of at least 20 cm.

In still another variant, the microwave emitters can have a variable

power and excite the resonant cavity by means of an insulator which absorbs the wave reflected by the cavity while protecting the emitters. The wave reflected by the resonant cavity, in particular during transitory excitation conditions, is advantageously absorbed by a traditional water load.

Other characteristics of the process and the device according to the invention will become evident from the description which follows of two embodiment examples, given as a guideline and nonlimiting, with reference to the attached drawings, in which:

— Figure 1 is a schematic drawing of the device according to the invention; and

— Figures 2 and 3 are perspective views of two respective variants of the resonant cavity containing the electrodeless tube, for the emission of ultraviolet radiation.

In the diagram in Figure 1, *1* indicates a microwave generator of suitable power, but generally chosen as 1,200 W under nominal conditions. This generator is excited by a modulator *2* and delivers a hyperfrequency radiation into an adjusted guide *3* connected to an insulator 4, which is itself coupled by another guide *5* to a water load *6*. The radiation usually has a frequency of 2,450 MHz.

The insulator is also connected by a third guide *7* to an appropriate coupling means (of the iris or half-wave antenna type) with a resonant cavity *8*. Over most or all of it, this latter contains an electrodeless tube *9* containing a pressurized gas and such that the effect of the electric field *E* component *10* created in the cavity *8* by the radiation from the emitter produces an emission of ultraviolet radiation, indicated in the figure by the wavy arrows, extending in a plane passing through the axis of the tube and perpendicular to

the short side of the cavity. A harmonizer *11* makes it possible to adjust the frequency in the cavity *8* if necessary, and in particular to bring it to the resonance according to an appropriate mode, so that an electric field antinode develops along the longitudinal dimension of the tube *9* which is equal to 20 or even 25 cm, thus permitting homogeneous and regularly distributed emission of the ultraviolet radiation.

In the example illustrated in Figure 2, the resonant cavity *8* containing the tube *9* has a prismatic form with a rectangular cross section; its long side *a* corresponds to a zero-order TE012 mode, parallel to the component *10* of the electric field *E*, and the sides *b* and c off the cross section correspond to orders 1 and 2 of the above mode. The guide *7* through which the microwave radiation is fed to the cavity *8* has an appropriate coupling slot *12*. In addition, opposite the guide *7* the cavity *8* has an open face *13*, in the plane of which there is a fine mesh *14* which allows the microwave radiation from the tube *9* to pass through along the arrows *15* with little alteration but prevents the escape of the hyperfrequency radiation from the cavity, where it thus remains confined.

The ultraviolet radiation thus produced homogeneously over the entire length of the tube *9* along the length of the tube *9* delimits a continuous strip *16* of the same size on a material *17* to be treated, which can be moved along the direction of the arrow *18* by any appropriate means (not shown) to allow a complete treatment of the entire surface, for example to dry a layer of ink or vanish coating it.

Figure 3 illustrates another variant of the cavity *8*, in which it is in the form of a chamber with a partially elliptical cross section. The inside wall *19* of the cavity *8* is preferably made of a material which is reflecting

for the ultraviolet radiation produced. Here the tube *9* is placed parallel to an axis of the chamber at one of the foci of the corresponding ellipse. The strip *16* formed on the sheet of material *17* in the region where the ultraviolet radiation is concentrated is positioned at the second focus of the same ellipse. In this variant, the opening *13* is covered by the mesh *14* to allow confinement of the hyperfrequency radiation but escape of the ultraviolet rays, as in the preceding example.

Thus a source of radiation is obtained which is perfectly suited to the treatments under consideration. It is simple in design and noticeably lower in cost than the solutions known in the art, requiring a greatly reduced microwave energy for a given supplied power. Nevertheless, it must be understood that the invention is not limited to the examples described, but encompasses all the variants within the scope of the man of the art.

CLAIM(S)

1. Process for the generation of ultraviolet radiation from a microwave source and an electrodeless tube (*9*) placed in a cavity (*8*) excited by means of a microwave generator (*1*) and resonated at an appropriate mode, characterized in that it consists in orienting the polarized stationary electric field (*E*) of constant amplitude parallel to the axis of the discharge tube (*9*) and overdimensioning the cavity so that this tube has its longitudinal dimension along a resonance antinode of the mode excited in the cavity.

2. Device for implementing the process according to Claim 1, characterized in that it has a resonant cavity (*8*), at least one microwave emitter (*1*) feeding into this cavity, a means of coupling (*7*) between the cavity and the emitter, a device (*11*) for adjusting the frequency tuning of the cavity, and a long electrodeless tube (*9*) containing a gas at a given pressure, placed in the cavity along the direction of the electric field (*E*) component for the excited mode, whereby the cavity (*8*) is overdimensioned so that said component has a resonance antinode along the length of the tube.

3. Device according to Claim 2, characterized in that the cavity (*8*) is prismatic and has a rectangular cross section to allow the excitation of the TE012 mode of tha hyperfrequency radiation, whereby the tube (*9*) is placed along the zero-order direction of the mode.

4. Device according to Claim 2, characterized in that the cavity (*8*) is cylindrical with a partially elliptical cross section, where by the tube (*9*) is placed along one of the foci of the cavity.

5. Device according to Claim 4, characterized in that the cavity (*8*) has a polished reflecting wall (*19*) making it possible to focus the ultraviolet radiation emitted by the tube (*9*) at the other focus of the cavity, excited on

the TM010 mode of the hyperfrequency radiation.

6. Device according to any of Claims 2-5, characterized in that the cavity (8) has an open side (13) parallel to the tube (9) and consisting of a fine mesh (14) transparent to the ultraviolet radiation emitted by the tube and opaque to the hyperfrequency radiation.

7. Device according to Claim 2, characterized in that it has two microwave emitters of identical or very similar frequency, whereby the frequency difference is less than the passband of the resonant cavity (8), so that the effects of each emitter are additive.

8. Device according to any of Claims 2-7, characterized in that the frequency of the microwave radiation is 2,450 MHz, whereby the tube mounted in the cavity has a length of at least 20 cm.

9. Device according to any of Claims 2-8, characterized in that the microwave emitter or emitters have variable power and excite the resonant cavity (8) by means of an insulator (2) which absorbs the wave reflected by the cavity and protects the emitter or emitters.

10. Device according to Claim 9, characterized in that the wave reflected by the resonant cavity (8) during the transitory excitation conditions is absorbed by a water load (6).

11. Application of the process according to Claim 1 to the treatment of materials in motion relative to the ultraviolet radiation produced.

FIG. 1

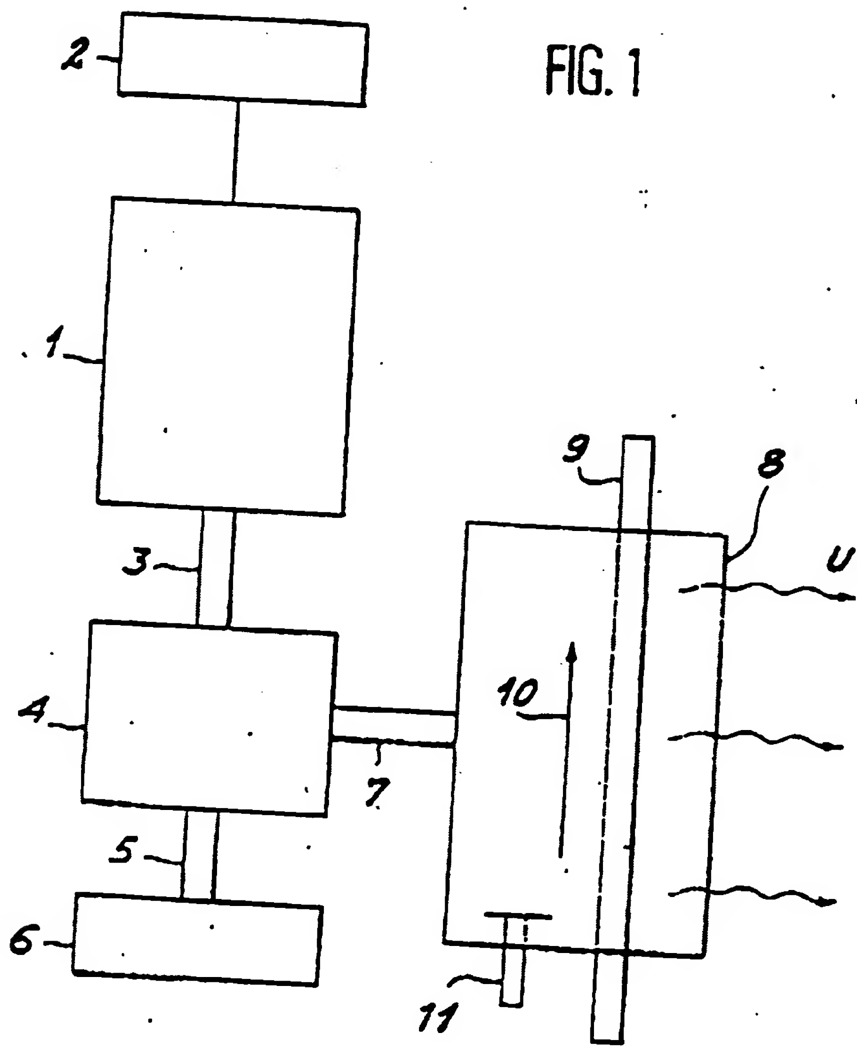

FIG. 2

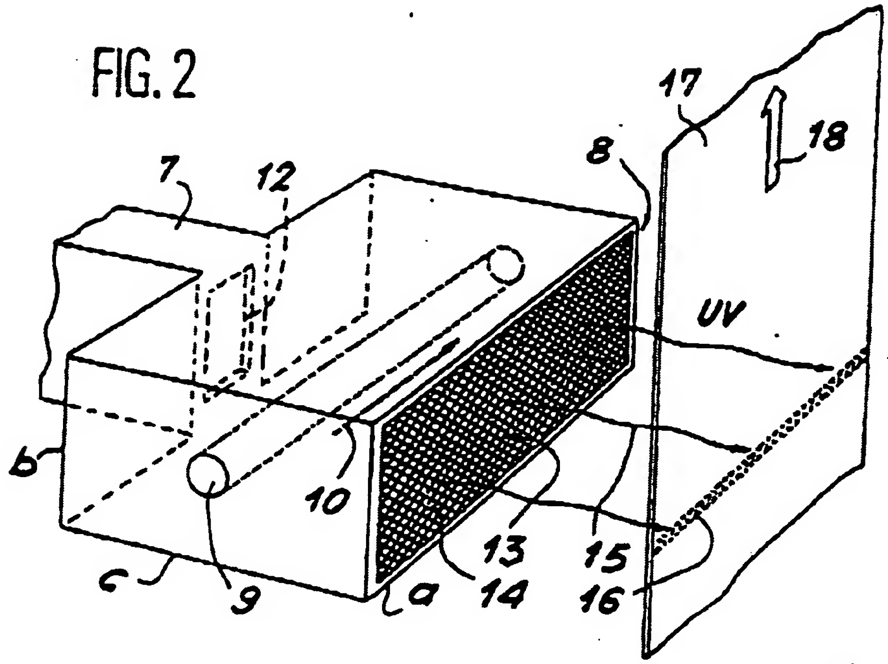

FIG. 3